STRATEGIES AND CHALLENGES FOR ACHIEVING TARGETS OF SUSTAINABLE DEVELOPMENT GOAL TOWARDS CLEAN AND AFFORDABLE ENERGY: A STUDY OF SELECTED INDIAN STATES

Synopsis

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1.0 Introduction

"Energy is the golden thread that connects economic growth, social equity, and environmental sustainability. With access to energy, people can study, go to university, get a job, start a business – and reach their full potential."

- Ban Ki-moon,
Former Secretary-General of the United Nations

Energy is the driving force behind all life on Earth, from the power that fuels our bodies to the electricity that lights our homes. Throughout history, humans have constantly sought out new sources of energy to sustain their civilizations and enhance their quality of life. The evolution of energy usage can be traced back to the earliest human societies, who relied on fire for warmth, cooking, and protection. As technology advanced, humans harnessed the power of wind and water to grind grains and power machines. The Industrial Revolution in the 18th and 19th centuries saw the widespread adoption of coal and later petroleum as the primary sources of energy for industry and transportation. Today, our dependence on fossil fuels for energy has reached unprecedented levels, leading to widespread environmental degradation and climate change. Furthermore, collecting and processing fossil fuels can cause habitat loss, air and water pollution, and other environmental issues. Energy consumption can have far-reaching environmental ramifications for ecosystems, public health, and the planet's overall well-being. Energy is by far the main contributor to climate change. It accounts for 73 percent of human caused greenhouse gases (UNDP). To overcome these difficulties, a shift to cleaner, more sustainable energy sources is critical. Increasing the use of renewable energy sources such as solar, wind, and hydropower reduces greenhouse gas emissions while simultaneously improving energy security and promoting local economic growth. While prioritizing renewables, minimizing dependence on non-renewables for a lower carbon footprint is vital. Balancing energy production with per capita consumption reduction, especially with a growing population, is key to achieving net-zero emissions Ramasubramanian & Ramakrishna (2023**)**. The United Nations Sustainable Development Goal 7 emphasizes investing in research and innovation to develop technologies that enable the decarbonization of energy systems, which leads to a more sustainable future.

1.1 Sustainable Development Goals

The Agenda 2030 for Sustainable Development is an action plan based on UN Member States commitments, with the primary goal of protecting the planet and ensuring all people enjoy peace and

prosperity. In 2000, the United Nations member countries promised to achieve the Millennium Development Goals (MDGs) by 2015. The UN General Assembly adopted a new global climate change agreement on September 25, 2015, following the end of the MDGs. On that day, 193 Member States from around the world pledged to support Agenda 2030, a UN-led program that is part of the United Nations Development Programme and addresses 17 Sustainable Development Goals (SDGs), which are further divided into 169 goals to be met. The United Nations member countries are committed to mobilizing the resources needed to achieve the Goals through partnerships that prioritizes the needs of the poorest and most vulnerable. The SDGs represent a path to sustainable development that tackles economic, social, and environmental issues, allowing us to go from commitment to action.

1.2 Sustainable Development Goal 7: Clean and Affordable Energy in Global Scenario

Energy is a critical issue globally, affecting employment, security, climate change, food production, and income growth. Universal access to electricity is essential for sustainable development goals. Between 2000 and 2018, the United Nations Development Programme (UNDP) reported an increase in the percentage of people with access to electricity from 78% to 90%, while the number of persons without power decreased to 789 million. With the global population expanding, the need for cost-effective energy will rise. Approximately one in 10 individuals now do not have access to electricity, with the majority residing in rural regions of developing countries. Moreover, over a third of the world's population, approximately 2.8 billion people, depend on harmful and environmentally damaging fuels like- biomass and excrement cakes for cooking. Although, the emerging nations have made significant financial advancements, yet the households are facing challenges when it comes to the access of the clean and efficient energy (Katoch et al, 2022). The UNDP emphasizes expanding infrastructure and upgrading technology to provide clean and more efficient energy that ensures widespread access to modern energy services, enhances energy efficiency, and promotes renewable sources. To achieve SDG 7 by 2030, investing in renewable energy sources like solar, wind, and thermal energy is crucial.

The main objective of the SDG 7 is following according to UN:

“To ensure access to affordable, reliable, sustainable and modern energy for all.”

The United Nations outlines various targets for the year 2030 to achieve this goal:

7.1 Ensure universal access to affordable, reliable and modern energy services.

7.2 Increase substantially the share of renewable energy in the global energy mix.

7.3 Double the global rate of improvement energy efficiency.

7.A Enhance international cooperation to facilitate access to clean energy research and technology and promote investment in energy infrastructure and clean energy technology.

7.B Expand infrastructure and upgrade technology for supplying modern and sustainable energy services for all in developing countries, especially the least developed countries, small island developing states and landlocked developing countries.

(Source: https://www.undp.org/sustainable-development-goals/affordable-and-clean-energy)

1.3 Concepts and Definitions

The International Energy Agency (IEA) defines energy access as "a household having reliable and affordable access to both clean cooking facilities and to electricity, which is enough to supply a basic bundle of energy services initially, and then an increasing level of electricity over time to reach the regional average".

According to Environmental and Energy Study Institute energy efficiency simply means using less energy to perform the same task - that is, eliminating energy waste. By IEA Energy efficiency is "the ratio of output of performance, service, goods or energy, to input of energy".

Renewable energy is energy derived from natural sources that are replenished at a higher rate than they are consumed. Sunlight and wind, for example, are such sources that are constantly being replenished. Renewable energy sources are plentiful and all around us. Fossil fuels - coal, oil and gas - on the other hand, are non-renewable resources that take hundreds of millions of years to form.

1.4 Overview of SDGs and Goal 7- Clean & Affordable Energy in India

India is critical in determining the success of the SDGs, globally. As one-sixth of humanity, India's actions directly impact global progress. At the UN Sustainable Development Summit in 2015, Prime Minister Narendra Modi emphasized that sustainable development in India would reverberate worldwide, leading to a world with fewer challenges and greater hope. NITI Aayog is the Nodal Agency in India which is responsible for the task of coordinating work on SDGs by adopting a synergistic approach. Ministry of Statistics and Programme Implementation (MoSPI) is responsible for indicator framework and has developed National Indicator Framework in consultation with Ministries,

States/UTs. At the State level, Planning Departments are the Nodal Department for implementation of SDGs in each State. According to the United Nations SDG Index and Dashboards Report 2023, which assesses countries progress towards the Sustainable Development Goals (SDGs), the SDG Index Rank of India is 112 out of 166 countries, with an overall index score of 63.5 percent. According to the IEA, India's share of the population with access to clean cooking was 64.3% in 2020, up from 35.6% in 2010. The proportion of the population with access to electricity increased significantly from 67.9% in 2010 to an impressive 99.8% in 2020. India's share of renewable energy in total final energy consumption was 17.7% in 2020, up from 12% in 2010. (SDG7: Data and Projections – Analysis - IEA).

The MoSPI has established the National Indicator Framework (NIF) to track and oversee the advancement towards Sustainable Development Goal (SDG) in the country. The below table of national indicators serves as a guide for monitoring progress towards achieving SDG 7 targets in India. It includes indicators concerning energy access, the adoption of renewable energy, energy efficiency, and universal electrification. Through the monitoring of these measures, policymakers can evaluate the impact of their strategies and efforts in advancing sustainable energy practices and guaranteeing energy security for everyone.

Table 1: MoSPI SDGs - National Indicator Framework, 2023 (as on 29.06.2023)

SDG 7: Ensure access to affordable, reliable, sustainable and modern energy for all
National indicator
Target 7.1: By 2030, ensure universal access to affordable, reliable and modern energy services
7.1.1: Percentage of households electrified 7.1.2: Percentage of household using clean cooking fuel
Target 7.2: By 2030, increase substantially the share of renewable energy in the global energy mix
7.2.1: Renewable energy share in the total installed electricity generation
Target 7.3: By 2030, double the global rate of improvement in energy efficiency
7.3.1: Energy intensity measured in terms of primary energy and GDP
Target 7.a: By 2030, enhance international cooperation to facilitate access to clean energy research and technology, including renewable energy, energy efficiency and advanced and cleaner fossil-fuel technology, and promote investment in energy infrastructure and clean energy technology
National Indicator is under development
Target 7.b: By 2030, expand infrastructure and upgrade technology for supplying modern and sustainable energy services for all in developing countries, in particular least developed countries, small island developing States and landlocked developing countries, in accordance with their respective programmes of support
7.b.1: Installed renewable energy generating capacity in the country

1.5 Government initiatives towards Clean and Affordable Energy

Kumar & Madlener (2016) India's substantial and sustained economic growth is putting enormous pressure on the country's energy resources. The threat of severe energy demand and supply imbalances is pervasive, requiring serious efforts by the Government of India to augment energy supplies. Most of India's electricity is produced by fossil fueled power plants, which are the source of CO2 emissions. In this case, renewable energy sources play a vital role in securing sustainable energy without environmental emissions. The Indian government is working towards Sustainable Development Goal 7 (SDG 7) by implementing various measures, including the National Solar Mission, which aims to position India as a leading player in solar energy. The government has also implemented initiatives like the Deen Dayal Upadhyaya Gram Jyoti Yojana and the Pradhan Mantri Sahaj Bijli Har Ghar Yojana (Saubhagya) to ensure energy connectivity in rural areas The Ujala scheme has distributed energy-efficient LED lamps to mitigate energy use. The International Solar Alliance (ISA) is a significant initiative that unites nations with abundant solar resources to use solar energy and reduce reliance on non-renewable fossil fuels. The FAME India scheme encourages the use of electric and hybrid vehicles to reduce emissions from the transportation sector (www.pib.gov.in). India aims to reach 40% of its total installed electric power capacity from non-fossil fuel-based energy sources by 2030, demonstrating its commitment to clean energy.

2.0 Review of Literature

The review of literature in the context of SDG 7 is divided into four categories: regulatory and governance frameworks, initiatives, goal-related studies, and the exploration of various energy scenarios. These categories offer a comprehensive view of how various stakeholders are working to ensure that everyone has access to affordable, reliable, sustainable, and modern energy. By examining these various perspectives, a more comprehensive understanding of the energy goal can be achieved. Review of some prominent studies are presented below.

2.1 Regulatory and Governance:

NITI Aayog, the Government of India's premier think tank, has been entrusted with the task of coordinating the SDGs. States have also been advised to undertake a similar mapping of their schemes, including centrally sponsored schemes. In 2016, **MoSPI** created a list of national indicators using

existing data. A national consultation workshop was held with Central Ministries/Departments and State Governments to review the proposed indicators. The Ministry of Statistics and Programme Implementation (MoSPI) created a National Indicator Framework (NIF) with 306 indicators, which will be crucial for monitoring Sustainable Development Goals (SDGs) and providing guidance to policymakers and program implementers.

Potdar et al. (2016) explored India's energy management strategies, including command-and-control, market-based, and voluntary approaches. Command-and-control regulations primarily target the power sector, while the Perform-Achieve-Trade initiative encourages energy-efficient technologies across eight industries. The voluntary regulations involve a wider population, including households, small and medium enterprises, and agriculture. These systems have helped develop energy-efficient technology, renewable energy, and a revamped power industry. These regulations have reduced energy sector emissions, aiding in climate change mitigation. The Perform-Achieve-Trade initiative awards certificates for each metric tonne of oil equivalent saved. **Gunningham (2012)** emphasizes the need for a "energy revolution" and industry reform to slow global warming. However, conflicts between energy security, climate change mitigation, and energy poverty often hinder such governance. The study examines the most necessary energy laws, regulations, and governance to address these issues and suggests networks, markets, or hierarchies as the best places to find solutions. The study highlights the need for strong national, regional, and international energy governance to bring about such a change.

Dobravec et al. (2021) emphasizes the need for new energy planning techniques and regulations for a sustainable energy system based on renewable energy, energy efficiency, decentralization, and cross-sector synergies. They argue that the success of energy transition and climate change mitigation cannot be solely attributed to federal government initiatives. They examined Austria's current energy planning governance system within the framework of multilevel governance (MLG), focusing on how local energy and climate initiatives align with national and EU objectives.

2.2 Initiatives:

Haw et al. (2006) Malaysia possesses ample renewable energy sources like sun, wind, hydro, and biomass. However, these sources are underutilised, and the country heavily relies on fossil fuels for electricity. The Malaysian government explored alternate sources of energy, focusing on renewable

energy, due to the rising prices of fossil fuels, particularly crude oil, on the global market. The Malaysian government has implemented five main initiatives on renewable energy: the fifth fuel policy under the 8th and 9th Malaysian plan, Energy efficiency in commercial buildings (MS1525), The Kyoto Protocol, The Malaysian building integrated Photovoltaic programme (MBIPV), and Biomass. **Kadir et al. (2013)** Disposing and treating municipal solid wastes (MSW) is difficult because of its large volume. Landfill dumping is limited in developed nations because of environmental concerns. Malaysia is investigating a dual strategy to address waste disposal and generate energy fuel. Energy recovery efforts concentrate on waste-to-energy (WTE) and refuse-derived fuel (RDF) systems for incinerating municipal solid waste (MSW).

Van & Scholtens (2015) study explored the transformation of urban areas towards renewable energy, highlighting the importance of community energy initiatives in achieving energy neutrality, zero carbon emissions, and zero impact on communities. The study uses a case study approach to demonstrate how local community energy initiatives contribute to a decentralized sustainable energy system, especially the development of a shared vision, the level of activities and the type of organisation are important factors of the strength of the 'local network'. **Blanchet (2015)** examined the impact of grassroots initiatives on urban energy systems, using a strategic action field framework to analyse conflicts related to Berlin's electricity grid municipalization. The study examines the formation and growth of grassroots initiatives and their engagement with local government and grid operators. The findings show that grassroots initiatives significantly influence local energy transition and policy execution, while also examining the extent and constraints of these initiatives within urban settings.

Kemausuor et al. (2011) discussed Ghana's efforts to improve energy accessibility, focusing on electricity, cooking fuels, and renewable energy. They argue that despite governments prioritising energy services in national development agendas, previous and current policies have failed to effectively improved access, especially in rural and peri-urban areas. They propose a comprehensive national energy policy that includes input from a broader population, sets specific goals, and outlines explicit tactics, including financial mechanisms, to achieve the targets. **Ackah et al. (2016)** studied Ghana's policy changes in the field of renewable energy during the previous 20 years. It also offers policy recommendations to expedite the implementation of renewable energy technologies in Ghana and the

connection between investments in renewable energy and sustainable development.

Xue et al. (2022) examined economic policy uncertainty (EPU) and the impact of renewable energy consumption on CO2 emissions in France, the third largest European country, from 1987 to 2019, while controlling for urbanisation and economic development. **Liu et al. (2023)** conducted a study on the impact of economic policy uncertainty (EPU) on the promotion of green growth domestic product (GGDP) in BRICS nations. They found that EPU reduces the Gross Global Domestic Product across all quantiles, with a significant negative effect at lower quantiles and weak correlation with GGDP at higher quantiles. The study recommends governments reduce uncertainty in economic policies to boost GGDP. **Chirambo (2018)** emphasizes the significance of rural electrification and linking energy access to agriculture and irrigation development in Africa, similar to Vietnam's situation. This strategy could help diversify economies and reduce negative views on Africa's growth and energy sectors. Power Africa, the Sustainable Energy for All Initiative, and the China South-South Climate Cooperation Fund can enhance financial and regulatory structures in Sub-Saharan Africa's energy industries. To achieve equitable growth as outlined in the Sustainable Development Goals, it is crucial to establish institutions that coordinate and unify investments and aid from various sources. **Kabeyi & Olanrewaju (2022)** proposes a roadmap for sustainable energy transition aligned with the Paris Agreement's goals. It focuses on reducing greenhouse gas emissions and ensuring reliable electricity generation.

2.3 Studies in relation to Sustainable Development Goal 7

Sustainable development is a term coined to ensure that development takes place in such a way that natural resources are sustained and passed on to the future generations unimpaired. **Ramasubramanian & Ramakrishna (2023)** analysis highlights challenges in environmental, social, and governance aspects, highlighting a gap in achieving the Sustainable Development Goal. They suggest improving greenhouse gas emissions estimates and establishing standardized life cycle assessment criteria. Balancing energy production with reducing per capita consumption is crucial for net-zero emissions

Etxeberria (2020) analysed how countries have evolved in terms of energy use and the subsequent influence on carbon emissions. The study analysed China, the European Union, and the United States of America in terms of the various objectives of Sustainable Development Goal 7 (SDG-7) and examined how the 1973 Oil Crisis and the Great Recession of 2008 impacted these countries/regions. Whereas,

Firoiu et al (2021) studied the progress of implementing SDG 7 targets in EU Member States five years after the Paris Agreement. They identified strong performance groups and highlighted countries needing more assistance to transition to a more environmentally friendly economy. The top-performing cluster expanded to eight EU countries by 2019, showing improved indicators and commitment to achieving SDG 7 targets.

Katekar & Deshmukh (2021) examined the progress of South Asian nations towards Sustainable Development Goal 7, focusing on modern energy access. Bhutan and India perform best, while Pakistan and Afghanistan struggle. The study highlights the importance of renewable energy sources in addressing energy shortages and saving money. To meet SDG 7, South Asian countries need to diversify their energy consumption patterns, increase cross-border energy commerce, and address energy-related challenges at policy, economic, technological, and information levels. By focusing on renewable energy sources, South Asian countries can address their energy-related challenges and contribute to a more sustainable future. **Burke & Melgar (2022)** evaluated and proposed energy sufficiency as a realistic policy solution to negative interconnections of SDG 7 for climate (SDG 13), the biophysical environment (SDG 14 and 15), and social justice (SDG 10), when connected to everlasting economic expansion. SDG 7 recommendations set economy-wide absolute and per capita energy use limits before technology and behaviour changes, shifting from energy surplus for some to energy sufficiency for all.

Santika et al. (2020) examined the effectiveness of Indonesia's energy policy in achieving universal energy access, boosting renewable energy use, and improving energy efficiency. They examine the laws and regulations to help achieve the Sustainable Development Goals. However, providing energy to the remaining 1.1 million households in the least developed areas remains challenging. Indonesia is working towards complete home electrification by 2030, but may not achieve universal access to clean cooking fuels and technology by that time. The current program, primarily targeting gas, may not reach impoverished households using solid biomass. **Ajao et al. (2021)** review showed that Nigeria has significant energy resources, but dismal access to affordable and sustainable energy has hindered economic and social growth. They provided an overview of Nigeria's energy resources and highlighted opportunities and obstacles for achieving energy security by 2030. It emphasizes the need for proactive government action, including clear energy policies, renewable energy integration, and waste reduction,

to meet Sustainable Development Goal (SDG 7) targets.

Ofori et al. (2023) highlighted the BRICS nations' leadership in promoting sustainable energy technology, particularly at the household level, as part of a shift towards sustainable societies. The study reveals that clean energy is crucial for environmental sustainability, human development, and green economic growth. Investments in green resources and technical innovation facilitate this shift. The study suggests policies to help BRICS nations achieve specific UN Sustainable Development Goals, particularly in transitioning to green energy (SDG-7), achieving environmental sustainability (SDG-13), and fostering innovation (SDG-9). **Katoch et al. (2022)** suggested the need for policy solutions to support disadvantaged groups and regions with limited access to clean and affordable energy. They emphasized the importance of formal education, particularly for rural women, in influencing their cooking fuel choices. And suggested that efficient planning and implementation of reforms can help achieve SDG 7 objectives by fostering cooperation between non-state organizations and the government in rural communities. **Jimmy (2023)** makes an attempt to understand the challenges encountered by India in achieving Sustainable development goals and offers suggestions to overcome them.

2.4 Studies on Energy Scenarios (Energy Assess, Energy Efficiency, Renewable Energy)

Pachauri & Spreng (2004) explored the relationship between energy access and poverty, using various methods to measure energy poverty. They estimated household energy needs using engineering calculations and normative assumptions, examined poverty in relation to energy sources, and combined access and consumption to examine their impact on households' wellbeing. Wellbeing was assessed in terms of access to clean and efficient energy sources and sufficiency in energy consumption, which was considered a complementary measure of poverty. **Mensah et al. (2014)** emphasized on the importance of energy access indicators in ensuring access to modern energy services for development. They assess Ghana's progress in providing modern energy services compared to other sub-Saharan countries. The report suggests additional actions to achieve universal electricity access and 50% access to LPG by 2020. The study also recommends conducting more research on variables important for monitoring progress in energy access that are not currently used in the country. The findings underscore the need for comprehensive planning and effective strategies for achieving energy access.

Ferrall et al. (2022) studied household electrical reliability in Tanzania, Kenya, and India using

common frameworks. They used data from solar home systems (SHS), solar pico grids, and national power grids. The study found that SHS delivered equivalent hours of lighting to local grid connections, but failures were less evenly distributed. The study also found that grid reliability assessments were sensitive to measurement techniques and assumptions, requiring high precision. The findings have important policy implications for alleviating energy poverty in the Global South. **Muller et al. (2021)** suggested that energy justice can help Africa meet its energy needs, but SDG 7 progress is slow and difficult to track. They propose that integrating justice into renewable energy strategies can help mitigate trade-offs and boost co-benefits. They map African renewable energy policy in 34 nations and outline four transition scenarios to illustrate the challenges of integrating justice into renewable energy strategies. They conclude that SDG 7 tracking should consider justice for a more comprehensive implementation that addresses socio-ecological justice and energy demands. **Khanal et al. (2019)** found that renewable energy technologies (RETs) can benefit individuals' socio-economically and environmentally, aid local climate change adaptation, and reduce vulnerability. They found that deploying all the technical potential of seven major RETs - biogas, improved water mill, stand-alone micro-hydro plants, mini-grid micro-hydro plants, solar PV home systems, mud-ICS, and metal-ICS could mitigate 4.45 million tonnes of CO2e emissions per year, with an average annual installation of 30.71 million tonnes between 2013 and 2030. These RETs require an initial technological investment of NRs 97 to NRs 23,247 per tonne of CO2e reduction. Thus, RETs can be a triple win strategy for climate-compatible development in Nepal, addressing mitigation, adaptation, and development.

Della Valle & Bertoldi (2022) addressed the pressing necessity to decrease energy usage in response to climate change. They highlight energy efficiency (EE) as a beneficial approach for all involved. Traditional approaches emphasise technologies and cost reduction, whereas behavioural economics and sociology provide additional viewpoints to tackle energy efficiency difficulties. The study intends to increase policy makers' understanding of transdisciplinary resources to improve energy efficiency policy recommendations. **Jahanger et al. (2023)** conducted a study on the relationship between energy consumption, power generation, natural resource use, and environmental damage in BRICS countries. They used the Method of Moment Quantile Regression (MMQR) and the Environmental Kuznets Curve (EKC) theory from 1990-2018. The study found that renewable energy sources and natural resources

are crucial in halting environmental degradation, with electricity use directly influencing environmental deterioration, highlighting the ecological impact of these countries.

Balachandra (2011) study found that in 2005, 364 million rural people lacked access to electricity and 726 million lacked modern cooking fuels in India, indicating a low effectiveness of government policies. The poorest households were most affected, with 93% relying on biomass for cooking and 62% lacking electricity access. Energy access growth rates have declined from double digits to around 4%. Regional variations showed that cooking access levels were 5.3 times higher in the top five states compared to the bottom five states, while electricity access was 3.4. **Shukla & Zia (2016)** explored India's response to rising energy demand, highlighting the country's efforts to improve energy availability and security. They examine the evolution of policy programs and their effectiveness in achieving energy efficiency and conservation. The study focuses on policy instruments that have contributed to energy savings and renewable energy integration in the building sector. The analysis evaluates the effectiveness of different policies and programs, as well as the key missions under the National Action Plan on Climate Change. **Yu et al. (2017)** predicted India's construction of 40 billion square meters of new buildings by 2050, accounting for 33% of India's energy consumption. Buildings, which account for 33% of India's energy, are expected to increase due to economic and population growth. The Energy Conservation Building Code (ECBC) is a method to enhance building energy efficiency. The study uses the Global Change Assessment Model to evaluate the growth in the buildings industry and the effects of building energy regulations in Gujarat. Without ECBC, energy consumption in commercial and urban residential buildings is projected to increase by 15 times and 4 times from 2010 to 2050. Implementing ECBC could lead to an additional 10% reduction in electricity consumption. **Kumar (2020)** highlights India's renewable energy development as a key driver of economic growth, energy security, and climate change response. With government assistance and an improving economy, India leads the world in renewable energy sectors. The government has created laws, programs, and a flexible environment to attract foreign investment and expand the renewable energy market. Renewable energy is expected to create many home jobs in the coming years. Kumar's review identifies challenges and provides recommendations for policymakers, innovators, investors, industries, stakeholders, researchers, and scientists.

Gillingham, Newell & Palmer (2009) study explored the economic principles influencing customer

choices towards energy efficiency and conservation. They analyse market barriers, market failures, and behavioural failures, providing an economic perspective on energy efficiency. The study evaluates policy action in energy-using product markets, focusing on policy efficacy and cost. research highlights the importance of addressing global warming and climate change, which threaten human life and the ecological balance, and the need for sustainable development goals. **Eras-Almeida & Egido-Aguilera (2020)** highlighted the challenges faced by underprivileged regions, particularly small islands and rural areas in emerging countries. These communities face shortages of goods and services, isolation from markets, limited human resources, and obstacles in achieving economies of scale. Their energy security is constrained by their reliance on foreign fuels, leading to higher electricity prices or making accessing electricity impractical.

3.0 Research Gap

On the basis of review of literature, the following research gaps have been identified:

- Very few studies were found on integration of renewable energy sources, energy efficiency measures, and energy access initiatives to achieve the targets of SDG 7 in a holistic and sustainable manner in India, making it a significant research gap for the study.
- Not much of the studies were found addressing the issue of implementation of SDG7 in different states across India as they differ in terms of energy access and renewable energy adoption.
- While some studies evaluate national renewable energy policies, there is a gap in evaluating state-level policies and their impact on achieving targets of clean and affordable energy.
- Additionally, an in-depth examination of barriers faced by different Indian states, such as financial constraints, infrastructure deficiencies, technological limitations, and socio-economic factors, is also lacking.

Addressing these research gaps would provide valuable insights into India's progress towards SDG 7 and help develop targeted interventions and strategies for sustainable energy access.

4.0 Need of the Study

Energy is a key driver of economic growth and development and plays a critical role in poverty alleviation and improving living standards. India is third largest consumer of the energy in the world (www.eia.com). Along with it, India also stands at the third rank in the world when it comes to the

greenhouse gas emission (www.statista.com). In addition to it, the demand for energy is expected to rise continually alongside the growth in population and economy of India. It is therefore important to study how Indian states are working towards achieving the targets of SDG 7 in order to ensure that they have a sustainable and secure energy supply to meet their future needs. By conducting this study, it will help to identify which states are performing well and which ones require more support in terms of policy implementation, infrastructure development, renewable energy promotion, etc. By understanding the current status and best practices of states that have made significant progress, benchmark goals can be set for others to learn from and aspire to. The study can help allocate resources and funding more effectively.

5.0 Research Questions

After conducting a thorough review of literature, the researcher has raised the following research questions:

- What is the current status of states in India in terms of energy access with reference to household electrification and availability of clean cooking fuel?
- How does renewable energy deployment and energy efficiency vary across states of India?
- How does the achievement of SDG 7 vary across different states in India, and what factors contribute to these variations?
- What are the major challenges hindering the achievement of SDG 7 in India?
- What policies and initiatives has the Indian government implemented to promote the achievement of SDG 7, and what has been their effectiveness?

6.0 Research Objectives

The proposed study has the following objectives:

1. To study the regulatory and governance framework to attain Sustainable Development Goals in India with reference to clean and affordable energy.
2. To study initiatives of central and state government with reference to energy access, energy efficiency and renewable energy.
3. To assess the performance of selected states of India with reference to attainment of SDG 7 (energy access, energy efficiency, renewable energy).

4. To conduct a SWOC analysis of selected states of India for effective attainment of clean and affordable energy.

5. To suggest state specific action plan for achievement of SDG 7.

7.0 Research Design and Methodology

7.1 Sample Design

India's share of global greenhouse gas (GHG) emissions was about 7% in 2021, making it the third largest emitter after China and the U.S. (statista.com). In order to select the sample of the proposed study, the states are selected depending upon the emission levels of greenhouse gases, as this is an indicator of energy consumption and the environmental impact of the same. The following table reflects the data on net greenhouse gas emissions by the individual states of India by 2018.

Table 2: Universe of the Study

States	**Net GHG Emissions (Mt CO2e)**	**% of India's Emissions**	
Uttar Pradesh	292.50	9.91%	**These 10 states account for 77.70% of the total GHG emission of India**
Maharashtra	290.33	9.83%	
Gujarat	286.98	9.72%	
Odisha	274.54	9.30%	
Chhattisgarh	253.86	8.60%	
Madhya Pradesh	214.92	7.28%	
West Bengal	187.11	6.34%	
Tamil Nadu	172.83	5.85%	
Andhra Pradesh	168.8	5.72%	
Rajasthan	152.12	5.15%	
Karnataka	130.65	4.42%	
Jharkhand	115.20	3.90%	
Bihar	86.59	2.93%	
Haryana	75.72	2.56%	
Punjab	70.43	2.39%	
Telangana	66.56	2.26%	
Assam	32.77	1.11%	
Uttarakhand	11.83	0.40%	
Manipur	11.55	0.39%	
Nagaland	10.52	0.36%	
Arunachal Pradesh	7.42	0.25%	
Mizoram	6.39	0.22%	
Tripura	6.35	0.22%	
Meghalaya	5.67	0.19%	
Goa	5.40	0.18%	
Kerala	1.21	0.04%	
Himachal Pradesh	-9.21	-	
Sikkim	0.13	0.004%	
UT			

Delhi	23.86	0.81%	
Daman & Diu	2.04	0.07%	
Puducherry	2.02	0.07%	
Dadar & Nagar Haveli	1.74	0.06%	
Chandigarh	1.10	0.04%	
Andaman & Nicobar Islands	0.73	0.02%	
Lakshadweep	-0.06	-	
Jammu And Kashmir	-16.36	-	
India	**2952.87**	**-**	

Source: https://www.ghgplatform-india.org/

India being the universe of the proposed study, only the top 10 greenhouse gas emitting states will be taken as the sample as they account for the majority of emissions (77.70%). In addition, the selected states also account for 65.47% of India's population.

Table 3: Selected States of India for the Study (Sample)

Sample States	Net GHG Emissions (Mt CO2e)	% of India's Emissions	% of India's Population
Uttar Pradesh	292.50	9.91%	16.82%
Maharashtra	290.33	9.83%	9.17%
Gujarat	286.98	9.72%	5.08%
Odisha	274.54	9.30%	3.38%
Chhattisgarh	253.86	8.60%	2.15%
Madhya Pradesh	214.92	7.28%	6.14%
West Bengal	187.11	6.34%	7.30%
Tamil Nadu	172.83	5.85%	5.71%
Andhra Pradesh	168.80	5.72%	3.94%
Rajasthan	152.12	5.15%	5.78%
Total	**2294**	**77.70%**	**65.47%**

Source: Greenhouse Gas Platform India 2018 report.

7.2 Duration of Study: Year 2015 onwards

7.3 Data Source: The research study will be based on the secondary data which will be collected from various sources like research papers, research reports, government websites, publications of governing ministries, international organisations websites and reports. To mention few are NITI Aayog, The Ministry of Statistics and Programme Implementation (MoSPI), the Internation Energy Agency, United Nations websites.

7.4 Statistical Tool: Time Series Regression, CAGR, Spearman's along with Diagnostic Testing, Qualitative analysis using NVivo and Quantitative based analysis using CAGR, Time Series & Structural Modeling and other suitable test shall be used for analysing the data as per its nature and requirement.

7.5 Research Methodology

Sr. No.	Research Objectives	Research Methodology
1.	To study the regulatory and governance framework to attain Sustainable Development Goals in India with reference to clean and affordable energy.	To achieve this objective, the researcher will use Thematic Analysis
2.	To study initiatives of central and state government with reference to energy access, energy efficiency and renewable energy.	Thematic Analysis
3.	To assess the performance of selected states of India with reference to attainment of SDG 7 (energy access, energy efficiency and renewable energy).	To fulfil this objective, researcher will use Time Series Regression, CAGR, Spearman's Correlation Analysis
4.	To conduct a SWOC analysis of selected states of India for effective attainment of SDG 7.	Both qualitative analysis using NVivo and quantitative-based analysis using CAGR, Time Series & Structural Modeling will be used to accomplish this objective.
5.	To suggest state specific action plan for achievement of SDG 7.	On the basis of results and findings of the analysis of collected data, an action plan would be prepared

7.6 Overview of Statistical Tools to be used to analyse the data

An overview of the statistical tools that will be employed in the study, as mentioned earlier, is given below:

1) **Thematic analysis:** It is a valuable qualitative method for exploring patterns and meanings in existing information (such as policy documents, interviews, and reports).
2) **Time series analysis:** Time series analysis focuses on understanding patterns and trends in data collected at successive time intervals. Researcher will analyse historical data on energy consumption, renewable energy adoption, and related variables over time.
3) **Time Series Regression:** Time series regression combines regression techniques with time series data. It analyses relationships between a dependent variable and independent variables over time.
4) **Compound Annual Growth Rate (CAGR):** measures the average annual growth rate of an investment or variable over a specified period. The researcher will collect historical data on renewable energy capacity or adoption rates to calculate the compound annual growth rate (CAGR) to assess the average annual growth in renewable energy over a specified period. And to evaluate trends and compare growth rates across states.

5) **Structural Modeling:** is a powerful statistical technique used to analyse complex relationships among constructs (latent variables) and their indicators (observed variables). Aims to understand the underlying causal relationships between variables. It combines elements of factor analysis, path analysis, and regression.

8.0 Policy and Social Implications

The proposed study will have significant policy and social implications. SDG 7 aims to provide affordable, reliable, sustainable, and modern energy for all. The study will assist in identifying states that have made significant advancements towards the goal and others that have fallen behind from a policy perspective. This information will be crucial in formulating targeted policies and initiatives to address disparities and enhance fair access to energy resources. It can help allocate resources efficiently and prioritise areas needing immediate attention to accelerate progress. Socially, the study will highlight the variations in energy access and how it affects people's lives. It will emphasise challenges and the necessity for inclusive policies that cater to their particular requirements. This comprehensive comprehension will increase awareness and galvanise communities, civil society organisations, and individuals to support change and help achieve SDG 7.

9.0 Chapter plan

Chapter 1: Introduction

Chapter 2: Review of Literature

Chapter 3: Research Design and Methodology

Chapter 4: Analysis I-Regulatory Framework and Clean Energy Initiatives by the Government

Chapter 5: Analysis II-Performance of Selected States of India with reference to Attainment of SDG 7

Chapter 6: Findings, Suggested Action Plan and Conclusion

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